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Title: Multi-Mission Telecom Analysis Tool

Category: Presentation of Specific IT Work at JPL

Theme: A1.Missions

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Abstract:

In the early formulation phase of a mission it is critically important to have fast, easy to use, easy to integrate space vehicle subsystem analysis tools so that engineers can rapidly perform trade studies not only by themselves but in coordination with other subsystem engineers as well. The Multi-Mission Telecom Analysis Tool (MMTAT) is designed for just this purpose. Using parameterized input and models based on the Deep Space Mission Systems Telecommunications Link Design Handbook (810-005), MMTAT provides high fidelity models of the telecom subsystem that can be run on a standard desktop computer for a fast and accurate telecom link analysis. Since MMTAT is new, it remains to be seen exactly how much faster the design process can be using it. However, MMTAT's architecture is based on the architecture of the successful Multi-Mission Power Analysis Tool (MMPAT) which reduced power subsytem design time on MER and DI from about 6 weeks to a few days.

MMTAT is an easy to use, easy to integrate, JPL developed, multi-platform analysis tool written in C and is distributed as a standalone application with a graphical user interface (GUI) or as a linkable library with a well-defined set of application program interface (API) calls. As a standalone application, MMTAT provides the user with two types of output, graphical and text. The graphs allow the user to quickly see changes in telecom performance when input parameters are modified. A delimited text file is generated at the end of each run that can be read by any spreadsheet program. As an easy to integrate linkable library, MMTAT's API lets the user control the simulation engine as well as change parameters during a simulation run. It also allows results to be output at the end of an entire run or retrieved via a function call at any timestep.

With desktop computers becoming more powerful, high fidelity multi-mission analysis tools, such as MMTAT, can now be used early in the mission life cycle. This reduces cost because system engineers are able to identify design problems before any hardware is built and because new telecom simulation models do not need to be developed for every mission. Since MMTAT is easy to integrate it can be used in virtually any simulation environment as well as in other software applications that need to predict or optimize the state of a telecom subsystem. Models that have been validated on previous missions enhance mission safety by insuring that future results of the simulation are accurate.

Multi-Mission Telecom Analysis Tool (MMTAT)

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Agenda

- Contributors
- MMTAT Overview
- Requirements
- Key Features
- Software Structure
- Models
- Input Profile
- Output
- API

Contributors

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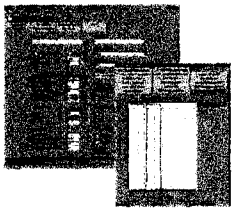
MMTAT Overview



- Software Simulation of Spacecraft Telecom Subsystem and DSN Ground Stations
  - Performs a link analysis based on spacecraft telecom subsystem parameters, DSN ground station selection and command and telemetry parameters.
- Models Multiple Mission Types
  - Heliocentric orbiter, Planetary Orbiter (FY03), Lander (FY03)

High-Level Requirements

- Develop a model that:
  - is applicable to a variety of mission phases, mission types, and hardware configurations.
  - is a JPL "in-house" capability.
  - provides high fidelity results *early in the design phase*
  - supports rapid trade studies during formulation and implementation phases.
  - supports mission planning and sequencing efforts.

Additional Requirements

- Intuitive ***graphical user interface*** (GUI) for relatively easy use.
- ***Fully parameterized inputs*** to provide flexibility and high re-use value.
- Built-in telecom subsystem configurations to provide a ***flexible*** modeling environment.
- ***Well-defined interface*** for use with other software programs, such as APGEN.
- Highly ***upgradeable and expandable*** to facilitate the addition of new or improved algorithms.
- Thoroughly ***documented*** to support peer and content reviews and to provide training.

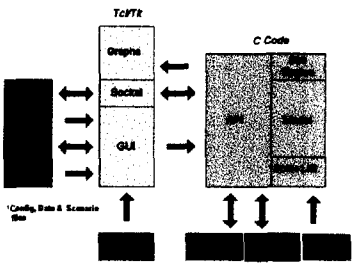
Key Features

- Multiple Mission Types: helio orbiter, lander (FY03), orbiter (FY03)
- Runs faster than real time (~17000:1 w/ 200sec step)
- Any parameter can be changed during a simulation run
- SPICE library integrated
- Intuitive Graphical User Interface (GUI)
- Graphical and tabular output
- On-line help
- No licenses, no cost to use
- Available for Windows, Linux, Solaris and eventually Mac (FY03)

Software Structure

- Tcl/Tk has been used to develop the graphical user interface.
  - Portable across platforms.
  - Socket interface already in place for interface to other systems.
  - Look and feel of a commercial Windows application.
  - "Tabbed" input structure and graph "tear-off" capabilities
- C-code contains the real "guts" of the model.
  - "Modular" and "object-based" coding approach.
  - Deploys as a linkable library for inclusion in other tools such as APGEN
  - Linked with SPICE, a highly accurate model of the solar system and of a spacecrafts orbit, attitude and antenna orientation

Architecture



Models

- DSN Ground Station
- Spacecraft Hardware
- Up/Down Link Performance

DSN Ground Station Model

- Based on current 810-005 Transmit/Receive Characteristics
  - Block V Receiver
  - Power Amplifiers
  - Low-Noise Amplifiers
  - Weather Conditions (limited)

Spacecraft Hardware Models

- Antenna Power/Gain/Losses
- Antenna Pattern
  - Provided from Test Data
  - Provide "ballpark" Data
  - Use "zero pattern" Data
- SDST (Small Deep Space Transponder)
  - Current models apply to Mars Odyssey, MER and Deep Impact
- Antenna orientation via SPICE

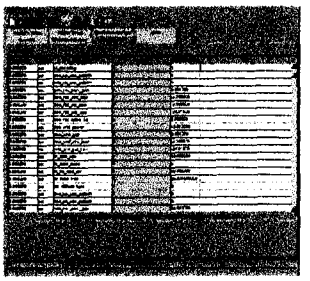
Up/Down Link Performance Models

- Power to Noise in Carrier/Ranging/Data Channels
- Differential One-Way Ranging
- Data Rate Capabilities
- Different Coding Schemes (Downlink)
  - None
  - Convolutional Encoding
  - Reed-Solomon concatenated with Convolutional Encoding
  - Limited Turbo Codes (Current 810-005 only provides models for two)

Input Profile

- Allows the user to change any parameter during a simulation run
  - Simulate changing weather conditions
  - Handoff of downlink/uplink from one ground station to another
  - Change from one spacecraft antenna to another
  - More...
- As a linked library, simulation keeps track of any parameters that have been changed
  - After a simulation run these changed parameters can then be written out as an input profile and then ingested into the standalone version

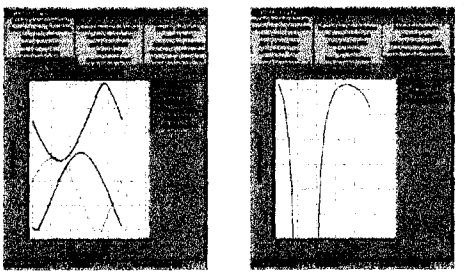
Input Profile



Output Files

- Tab delimited text file
  - Results of interest at each time step with column headings
  - Most spreadsheet programs (e.g. Excel) will ingest
- Design control tables
  - FY03

Graphs



API

- All external interfaces communicate with the model through the API
- API functions use strings for parameters and return values
- Allows caller to control simulation flow and check for errors after each call to the API
- Parameters can be queried/changed at any time
- Variables and results can be queried ant any time